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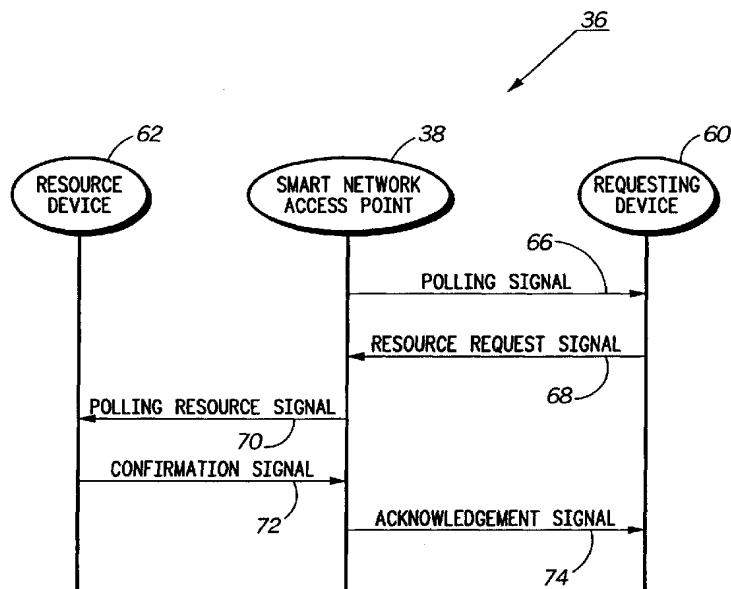
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(54) Title: SYSTEM FOR DYNAMIC PROCESS ASSIGNMENT IN A LOCAL AREA NETWORK AND METHOD THEREFOR

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(57) Abstract: A system (10) for dynamic process assignment among a plurality of devices (40) includes an initial coordinator (38), a requesting device (60), and a resource device (62). The initial coordinator (38) includes a list of available resources (56) for each device of the plurality of devices (40). The requesting device (60) requests the use of a desired resource. In response to the request from the requesting device (60), the initial coordinator (38) identifies an available resource associated with one of the plurality of devices (40) for use by the requesting device (60) as the desired resource.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SYSTEM FOR DYNAMIC PROCESS ASSIGNMENT
IN A LOCAL AREA NETWORK AND METHOD THEREFOR

BACKGROUND OF THE INVENTION

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FIELD OF THE INVENTION

This invention relates in general to wireless communication systems and in particular to wireless communication systems incorporating dynamic process assignment.

10

DESCRIPTION OF THE RELATED ART

Short-range wireless communication and personal area networks will soon proliferate in common household products as well as mobile business products. Currently many products that have wireless capability are incompatible. Short-range wireless local area network (WLAN) protocols such as Bluetooth, HomeRF, and IEEE 802.11 provide an avenue towards compatibility. These short-range WLAN protocols operate at lower power and over shorter distances. These short-range WLAN protocols generally use unlicensed spectrum and require minimal coordination with the secondary communication protocol of the device (e.g., GSM, IS-95, IS-136, ReFLEX™, etc.).

Short-range wireless communication can be, for example, provided using an Infrared Data Association (IrDA) communication standard. IrDA is a point-to-point, narrow angle (30 degree cone), ad-hoc data transmission standard designed to operate over a distance of zero (0) to one (1) meter and at speeds of 9600 bits per second to 16 Mega bits per second. Similarly, the short-range communication can be provided using a Bluetooth communication standard. Bluetooth is a short range, point-to-multipoint voice and data transfer standard designed to operate over a nominal distance of ten (10) centimeters to ten (10) meters, but can be extended to one hundred (100) meters by increasing transmit power. Bluetooth operates in the 2.4 Gigahertz radio frequency range.

Short-range WLAN protocols such as IrDA and Bluetooth technology allow for the replacement of the many proprietary cables that connect one device to another with one universal short-range radio link. Short range WLAN protocol technology could replace the cumbersome cables used today

5 to connect a laptop to a cellular telephone or between other devices such as printers, personal digital assistants, desktops, fax machines, keyboards, joysticks or virtually any other digital device. Refrigerators, microwave ovens, dish washers, laundry washers & dryers, stereo, television, digital video disks, video games, lighting, irrigation, cooling and heating systems among others

10 may also take advantage of such short-range radio links.

Potential applications of these low-power, short-range, protocols are wireless connection of peripherals devices, high-speed data transfers to desktop computers and wireline networks, and establishment of short-range "ad hoc networks" between similar wireless communication devices. Two or

15 more units sharing the same channel is called an ad hoc network. In an ad hoc network one of the units functions as the master while the others function as slaves. For example, in a Bluetooth system, up to seven active slaves can exist in an ad hoc network but many more can remain locked to the same master in a so-called parked state. These parked units cannot be active on

20 the channel, but remain synchronized to the master. The master always controls the channel access for both the active and the parked units. The master in a Bluetooth system controls the traffic across the channel using a polling scheme. Once an ad hoc network has been established, master-slave roles can be exchanged. To avoid collisions, communication between two

25 slaves can only be accomplished through the master unit.

Many short-range communication WLANs such as the Bluetooth system further supports scatternets. A scatternet is the combination of two or more ad hoc networks with overlapping coverage area. Each ad hoc network can only have one master. However, a master in one ad hoc network can

30 participate as a slave in another and slaves can also participate in different ad hoc networks on a time division multiplex basis. Ad hoc networks within a scatternet are not time or frequency synchronized. Each ad hoc network uses its own hopping sequence.

The devices participating in an ad hoc network each include different processes capabilities. For example, some have more processing power, some have access to an unlimited power source, and some include a variety of powerful applications. Further, usage profiles vary for each device. For

5 example, printers may have a low usage profile and thus have some additional free computing time. Similarly, the personal computer in an office may have a high usage profile but may be the only device that has a particular application on board. One personal computer may have access to a higher speed modem.

10 What is needed is a system and method for dynamically assigning processes within a WLAN such as an ad hoc network to optimize the shared capabilities of each individual unit within the network.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

15 The present invention will be described by way of exemplary embodiments, but not limitations, illustrated in the accompanying drawings in which like references denote similar elements, and in which:

FIG. 1 is a block diagram of a communication system having devices that operate on both a short range and a secondary protocol;

20 FIG. 2 is a block diagram of a block diagram of an ad hoc network for use within the communication system of FIG. 1;

FIG. 3 is a block diagram of a smart network access point for use in the ad hoc network of FIG. 2 in accordance with the present invention;

25 FIG. 4 illustrates the communication between devices within the ad hoc network of FIG. 2 in accordance with the present invention; and

FIG. 5 is a flow chart illustrating the operation of the ad hoc network of FIG. 2 in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

30 As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention, which may be embodied

in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed 5 structure. Further, the terms and phrases used herein are not intended to be limiting; but rather, to provide an understandable description of the invention.

Referring to FIG. 1, a communication system 10 having devices that operate on a short-range protocol system 14 and preferably on a secondary protocol system 12 is illustrated. The secondary protocol system 12 as shown 10 in FIG. 1 includes a base station 16 with a co-located base transmitter 18 and base receiver 20 covering a wide area range 22 as shown. A typical secondary protocol could be Motorola's ReFLEX™ messaging protocol.

It will be appreciated by one of ordinary skill in the art that the secondary protocol system 12, in accordance with the present invention, can function 15 utilizing any wireless RF channel, for example, a one or two-way pager channel, a mobile cellular telephone channel, or a mobile radio channel. Similarly, it will be appreciated by one of ordinary skill in the art that the secondary protocol system 12 can function utilizing other types of 20 communication channels such as infrared channels, audio channels, and local area networks. In the following description, the term "secondary protocol system" refers to any of the systems mentioned above or an equivalent.

In one embodiment, each of the devices (i.e.: a personal computer 24, a wireless communication device 26, a personal digital assistant 28, a printer 30, and a computer 32) is a device using a short-range WLAN protocol, such 25 as Bluetooth technology. It will be appreciated by one of ordinary skill in the art that the short-range WLAN protocol, in accordance with the present invention, can function utilizing any short-range wireless protocol such as IrDA, HomeRF, and IEEE 802.11. Using the short-range WLAN protocol, each device will establish a list of "partners",

30 Using the short-range WLAN protocol, a first device, such as the personal computer 24 (User A), and one or more of the potential partner

devices (the wireless communication device **26**, the personal digital assistant **28**, the printer **30**, or the computer **32**) agree to form an ad-hoc network.

This network is defined by a list of active partners stored in Unit A. The list may contain available resources for each device, including battery life, 5 access to wide area networks, application availability, utilization, etc.

FIG. 2 is a block diagram of an ad-hoc network **36** for use within the communication system **10** of FIG. 1 in accordance with the present invention. The ad hoc network **36**, for example, can be a subset of the short-range protocol system **14** of FIG. 1. The ad hoc network **36** includes a plurality of 10 devices **40** such as the wireless communication device **26**, the personal digital assistant **28**, the printer **30**, and the computer **32**. In one embodiment, as illustrated in FIG. 2, the ad hoc network **36** further includes a smart network access point **38**. Within the ad hoc network **36** of FIG. 2, an initial coordinator functions as the master and the plurality of devices **40** function as the slaves. 15 The initial coordinator, for example, can be the smart network access point **38** or alternatively, the initial coordinator can be one of the plurality of devices **40**.

It will be appreciated by one of ordinary skill in the art that each of the plurality of devices **40** in accordance with the present invention, can be a mobile cellular telephone, a mobile radio data terminal, a mobile cellular 20 telephone having an attached data terminal, or a two way pager, such as the “Pagewriter 2000X” manufactured by Motorola Inc. of Schaumburg, Illinois. Similarly, each of the plurality of devices **40**, in accordance with the present invention, can be a printer, a personal computer, or a personal digital 25 assistant. In the following description, the term “device” refers to any of the devices mentioned above or an equivalent.

It will be further appreciated by one of ordinary skill in the art that the ad hoc network **36** can include only the plurality of devices **40** in one embodiment without the use of the smart network access point **38**. In this alternative embodiment, one or more of the plurality of devices can take the role of initial 30 coordinator or resource manager.

As illustrated in FIG. 3 in an embodiment where the smart network access point **38** functions as the initial coordinator, the smart network access

point **38** preferably functions as a transformer from the short-range WLAN protocol to the secondary network **12** such as a local area network (LAN) or a wireless communication system (see FIG. 1). It will be appreciated by one of ordinary skill in the art that one of the plurality of devices **40** alternatively can

5 function as the initial coordinator and that the functionality described herein for the smart network access point **38** can equally apply to one of the plurality of devices **40**. The smart network access point **38** includes an ad hoc network interface **42**, a secondary system interface **44**, a processor **46** and a resource management application **48**.

10 Coupled to the ad hoc network interface **42** and the secondary system interface **44** is the processor **46** utilizing conventional signal-processing techniques for processing received information. Preferably, the processor **46** is similar to the MC68328 micro controller manufactured by Motorola, Inc. of Schaumburg, Illinois. It will be appreciated by one of ordinary skill in the art 15 that other similar processors can be utilized for the processor **46**, and that additional processors of the same or alternative type can be utilized as required to handle the processing requirements of the processor **46**.

In a preferred embodiment, the initial coordinator, such as the smart network access point **38**, includes the resource management application **48** 20 coupled to the processor **46**. The smart network access point **38** performs resource management functions within the resource management application **48** using a processor command **50** sent from the processor **46**. The resource management application **48** sends an application response **52** in reply to the processor command **50**. The resource management application **48** preferably 25 includes a resource-tracking list **54**. The resource management application **48** can be hard coded or programmed into the smart network access point **38** during manufacturing, can be programmed over-the-air upon customer subscription, or can be a downloadable application. It will be appreciated by one of ordinary skill in the art that other programming methods can be utilized 30 for programming the resource management application **48** into the smart network access point **38**.

The resource management application **48** preferably is programmed to enable utilization of a required resource from the resource-tracking list **54**. The resource-tracking list **54** includes a plurality of resource information **56** for each of the plurality of devices **40** of the ad hoc network **36**. For example, the plurality of resource information **56** can include device battery life, device battery capacity, device processing power, and access to the secondary network for each of the plurality of devices **40**. The resource management application **48**, in response to the processor command **50**, preferably accesses the resource-tracking list **54**. The resource management application **48** is programmed to identify an available resource from the resource-tracking list **54** using the plurality of resource information **56** stored in the resource-tracking list **54** by using predetermined algorithms, as is well known in the art. The resource management application **48** is preferably programmed with a set of rules identifying the resource to allocate in response to the processor command **50**. When the resource management application **48** identifies the available resource, the resource management application **48** sends the application response **52** to the processor **46**. The processor **46**, in response to receipt of the application response **52**, enables the use of the available resource by the requesting device.

Referring back to FIG. 2, the present invention provides a novel way of dynamically assigning a particular task to one of the plurality of devices **40** within the ad hoc network **36**. For example, as illustrated in FIG. 2, the smart network access point **38** can be located in a public place and the plurality of devices **40** can initially be three devices, for example, the personal digital assistant **28**, the printer **30**, and the computer **32**. The smart network access point **38** and each of the plurality of devices **40** preferably operate using one of many secondary, short-range WLAN protocols as described herein. It will be appreciated by one of ordinary skill in the art that the secondary, short-range WLAN protocol, in accordance with the present invention, can function utilizing any short-range wireless protocol such as Bluetooth, IrDA, HomeRF, and IEEE 802.11. When a fourth device, such as the wireless communication device **26**, comes within the range of the smart network access point **38**, it can

decide to become part of the ad hoc network **36**. For example, it can request to be a member of the ad hoc network **36** for the purpose of downloading a long electronic mail document **58** (E-mail) originally written in a language other than English. The smart network access point **38** processes the request from 5 the wireless communication device **26** and identity from the resource-tracking list **54** (see FIG. 3) of the smart network access point **38**, the available resource to translate the E-mail document **58**. Further it instructs the resource identified to translate the email where to return the translated email

For example, when the smart network access point **38** has greater 10 resources available (memory, processing power, energy source) than the other plurality of devices **40**, the smart network access point **38** can run the translation application to translate the E-mail document **58**, while still serving the other three devices.

Alternatively, when the capacity of the smart network access point **38** is 15 low but still has enough processing power to download the document into another device such as the wireless communication device **26** but not run the application, the smart network access point **38** can assign the wireless communication device **26** to run the translation application itself to translate the E-mail document **58**.

20 Alternatively, when both the capacity of the smart network access point **38** and the battery life of the wireless communication device **26** are low, the smart network access point **38** downloads the E-mail document **58** to another device within the ad hoc network **36** that is capable of running the application such as the computer **32**. Once the computer **32** completes the task, it sends 25 the translated document back to the smart network access point **38**, which forwards this information to the wireless communication device **26**.

Alternatively, the computer **32** sends the translated document directly to the wireless communication device

26.

30 FIG. 4 illustrates one embodiment of the communication between the smart network access point **38**, a requesting device **60**, and a resource device **62** of the ad hoc network **36**. In FIG. 4, the smart network access point **38**

polls the requesting device **60** by transmitting polling signal **66** in an occupied bandwidth. Preferably, this transmission is of a standard Bluetooth 1.0 type transmission or an equivalent. The requesting device **60**, in response, requests a resource **64** that is dynamically selected by the smart network access point **38**. Initially, it is assumed that a polling signal **66** sent from the smart network access point **38** has just arrived at the requesting device **60** and the smart network access point **38** is maintaining the ad hoc network **36**, e.g., polling the plurality of devices **40** (not shown). When a poll by the smart network access point **38** is not scheduled, the requesting device **60** utilizes its internal resources for performing required tasks.

It will be appreciated by one of ordinary skill in the art that alternatively, the initial coordinator, for example the smart network access point **38** or one of the plurality of devices **40** sets the communication between two devices of the ad hoc network and thereafter the two devices communicate directly with each other without the interference of the initial coordinator.

It will be appreciated by one of ordinary skill in the art that the transmission, in accordance with the present invention, can function utilizing any short-range wireless protocol such as IrDA, HomeRF, and IEEE 802.11. The requesting device **60** then sends a resource request signal **68** to requests the usage of a resource from the ad hoc network **36** to the smart network access point **38**. The smart network access point **38** identifies the available resource within the ad hoc network **36** and sends a polling resource signal **70** to the resource device **62** to confirm use of the selected resource of the resource device **62**. The resource device **62** then sends a confirmation signal **72** to the smart network access point **38**. When the smart network access point **38** finds an acceptable resource, the smart network access point **38** sends an acknowledgement signal **74** acknowledging the request of the requesting device **60** including identification of the resource device **62**. When the smart network access point **38** finds the resource identified as unacceptable, the smart network access point **38** will ideally search the resource-tracking list **54** for the best alternative, which is then sent to the requesting device **60**.

FIG. 5 is a flow chart illustrating the one embodiment of the operation of the ad hoc network 36 of FIG. 2 in accordance with the present invention. In Step 76, a wireless connection is formed between two devices using one a WLAN protocol. Next, in Step 78, the two devices have stored in memory a common application. Alternatively, one or both devices can have access to the common application via the secondary protocol system 12. Next, in Step 80, one of the devices decides to run the common application. Next, in Step 82, both devices set a decision counter to zero. Next, in Step 84, the available excess energy of the two devices is compared. For example, one of the devices can have access to an unlimited power source. In this case, the use of this unlimited power source overrides the currently available energy capacity of the other device. In Step 86, when the battery life of the first device (D1) is lower than the second device (D2), the counter of D1 is incremented by one. In Step 88, when the battery life of D1 is greater than the battery life of D2, the available capacity of the two devices is compared. In Step 90, when the capacity of D1 is lower than the capacity of D2, the counter of D1 is incremented by one. In Step 92, when the capacity of D1 is greater than the capacity of D2, the processing power of the two devices is compared. In Step 94, when the capacity of D1 is lower than the capacity of D2, the counter of D1 is incremented by one. When the processing power of D1 is greater than the processing power of D2 in Step 92, and when the counter of D1 has been incremented by one in Steps 86, 90, and 94, next, in Step 96, the final counter value is calculated. Next, in Step 98, the counter value of D1 is compared to the counter value of D2. In Step 100, when the counter value of D1 is lower than the counter value of D2, D1 is used to run the common application. In Step 102, when the counter value of D1 is higher than the counter value of D2, D2 is used to run the common application. The process then resets to begin again at Step 76.

To illustrate the method of the present invention, consider a video cellular telephone, which has an application to perform the MPEG4 video compression and decompression. The raw video signal can require a data rate (bandwidth) of several hundred kilobits per second (kbps). When

compressed, the video signal can require as little as 28.8 kbps, depending upon the quality and size of the video image. For macro-cellular connections (i.e.: GSM cellular network) the compressed signal is transmitted over the wireless channel for bandwidth efficiency, in order to support many users.

- 5 The videophone performs both MPEG4 compression and decompression for transmitting and receiving the video signal. The same phone can also be used on a WLAN, which can support higher bandwidths, and typically fewer users. When the video phone connects with the smart network access point 38 using the WLAN protocol, the phone and the smart network access point
- 10 38 can communicate regarding available bandwidth, MIPs capabilities and devices' processors, and user battery status. As a result, the devices can make a decision for the smart network access point to do the processing intensive MPEG4 video compression and decompression and then transmit the uncompressed video signal to the user's device with a higher bandwidth
- 15 WLAN protocol. This saves battery power and potentially speeds up the video processing at the expense of consuming WLAN bandwidth and processing resources of the smart network access point. The decision of the smart network access point to perform the video compression and decompression can be made on a frame by frame basis, so the smart network
- 20 access point 38 can continue to handle other processes intermittently.

Although the invention has been described in terms of preferred embodiments, it will be obvious to those skilled in the art that various alterations and modifications may be made without departing from the invention. Accordingly, it is intended that all such alterations and 25 modifications be considered as within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

CLAIMS

1. An ad hoc network for dynamic process assignment among a plurality of devices, the ad hoc network comprising:
 - 5 a first device, wherein the first device functions as a resource manager, and further wherein the first device includes a list of available resources for each device of the plurality of devices; and
 - 10 a second device, wherein the second device requests the use of a desired resource,
 - 15 wherein, the first device, in response to the request from the second device identifies an available resource associated with one of the plurality of devices for use by the second device as the desired resource.
- 15 2. The ad hoc network for dynamic process assignment as recited in Claim 1 wherein the first device instructs the one of the plurality of devices to allow the use of its available resource by the second device in response to the first device identifying the available resource.
- 20 3. The ad hoc network for dynamic process assignment as recited in Claim 1 further comprising a smart network access point, wherein the smart network access point functions as the resource manager, and further wherein the smart network access point comprises:
 - 25 an ad hoc network interface,
 - a secondary system interface,
 - 30 a processor coupled between the ad hoc network interface and the secondary system interface, wherein the processor functions as a transformer between the ad hoc network interface and the secondary system, and
 - a resource management application coupled to the processor, wherein the resource management application includes a resource-tracking list having a plurality of resource information for each of the plurality of devices of the ad hoc network.

4. The ad hoc network for dynamic process alignment as recited in Claim 1 wherein the resource manager collects and automatically provides the list of available resources to the plurality of devices, and further wherein each of the plurality of devices stores the list of available resources.

5. A communication system for dynamic process assignment comprising:
 - a secondary protocol system; and
 - a short-range wireless local area network protocol system including a
- 5 plurality of devices, the short-range local area network protocol system comprising:
 - a first device, wherein the first device functions as a resource manager, and further wherein the first device includes a list of available resources for each device of the plurality of
 - 10 devices; and
 - a second device, wherein the second device requests the use of a desired resource,
 - wherein, the first device, in response to the request from the second device identifies an available resource associated with one
 - 15 of the plurality of devices for use by the second device as the desired resource.
6. The communication system for dynamic process assignment as recited in Claim 5 wherein the resource manager collects and automatically provides
- 20 the list of available resources to the plurality of devices, and further wherein each of the plurality of devices stores the list of available resources.
7. The communication system for dynamic process assignment as recited in Claim 5 wherein the first device, in response to the request from the second
- 25 device identifies an available resource associated with the secondary protocol system for use by the second device as the desired resource.

8. The communication system for dynamic process assignment as recited in Claim 5 further comprising a smart network access point, wherein the smart network access point functions as the resource manager, and further wherein
 - 5 the smart network access point comprises:
 - an ad hoc network interface,
 - a secondary system interface,
 - a processor coupled between the ad hoc network interface and the secondary system interface, wherein the processor functions as a transformer
 - 10 between the ad hoc network interface and the secondary system, and
 - a resource management application coupled to the processor, wherein the resource management application includes a resource-tracking list having a plurality of resource information for each of the plurality of devices of the ad hoc network.

9. Within an ad hoc network, a method for dynamic process assignment among a plurality of devices, the method comprising:

- 5 requesting a desired resource by a requesting device sending a resource request signal;
- identifying an available resource of a resource device within the plurality of devices corresponding to the desired resource;
- sending a polling resource signal to the resource device to confirm the
- 10 use of the available resource by the requesting device;
- sending a confirmation signal by the resource device to the requesting device.

10. Within an ad hoc network, a method for dynamic process assignment among a plurality of devices including an initial coordinator, a requesting device, and a resource device, the method comprising:
 - 5 polling the requesting device by the initial coordinator transmitting a polling signal in an occupied bandwidth;
 - requesting a desired resource by a requesting device sending a resource request signal to the initial coordinator;
 - 10 identifying an available resource of a resource device within the plurality of devices corresponding to the desired resource by the initial coordinator;
 - sending a polling resource signal by the initial coordinator to the resource device to confirm the use of the available resource by the requesting device;
 - 15 sending a confirmation signal by the resource device to the initial coordinator; and
 - sending an acknowledgment signal including identification of the resource device by the initial coordinator to the requesting device.

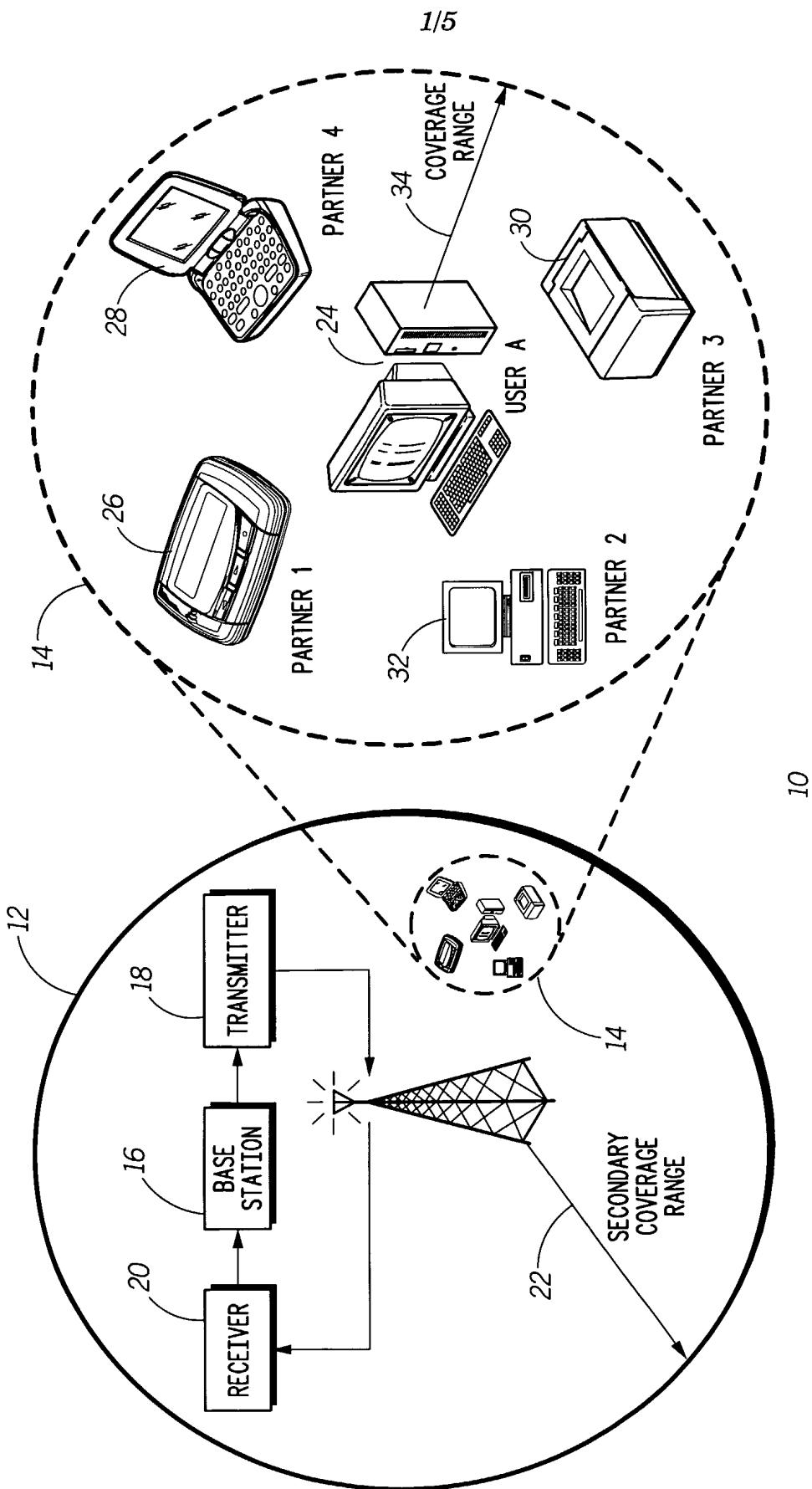
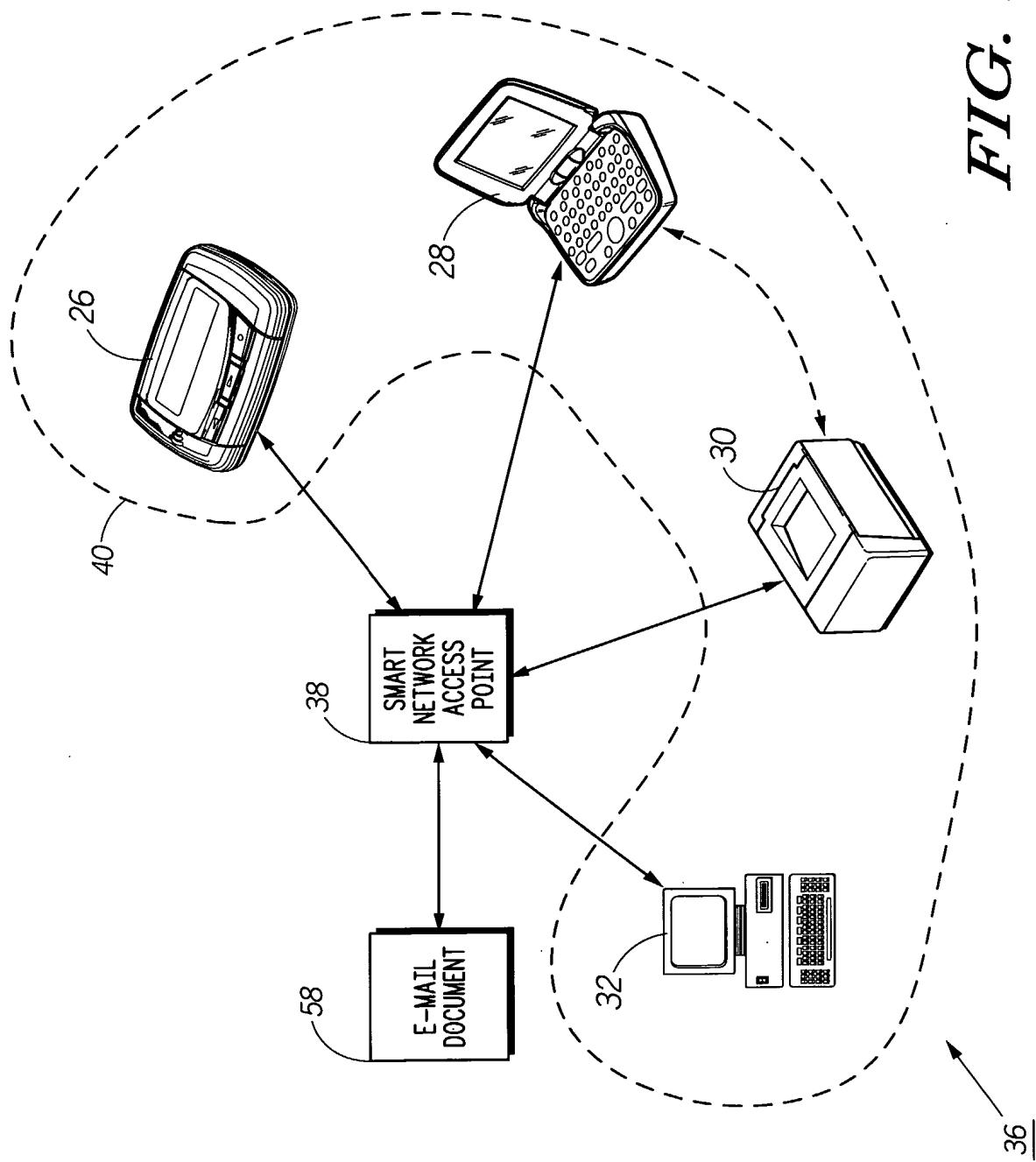


FIG. 1

FIG. 2



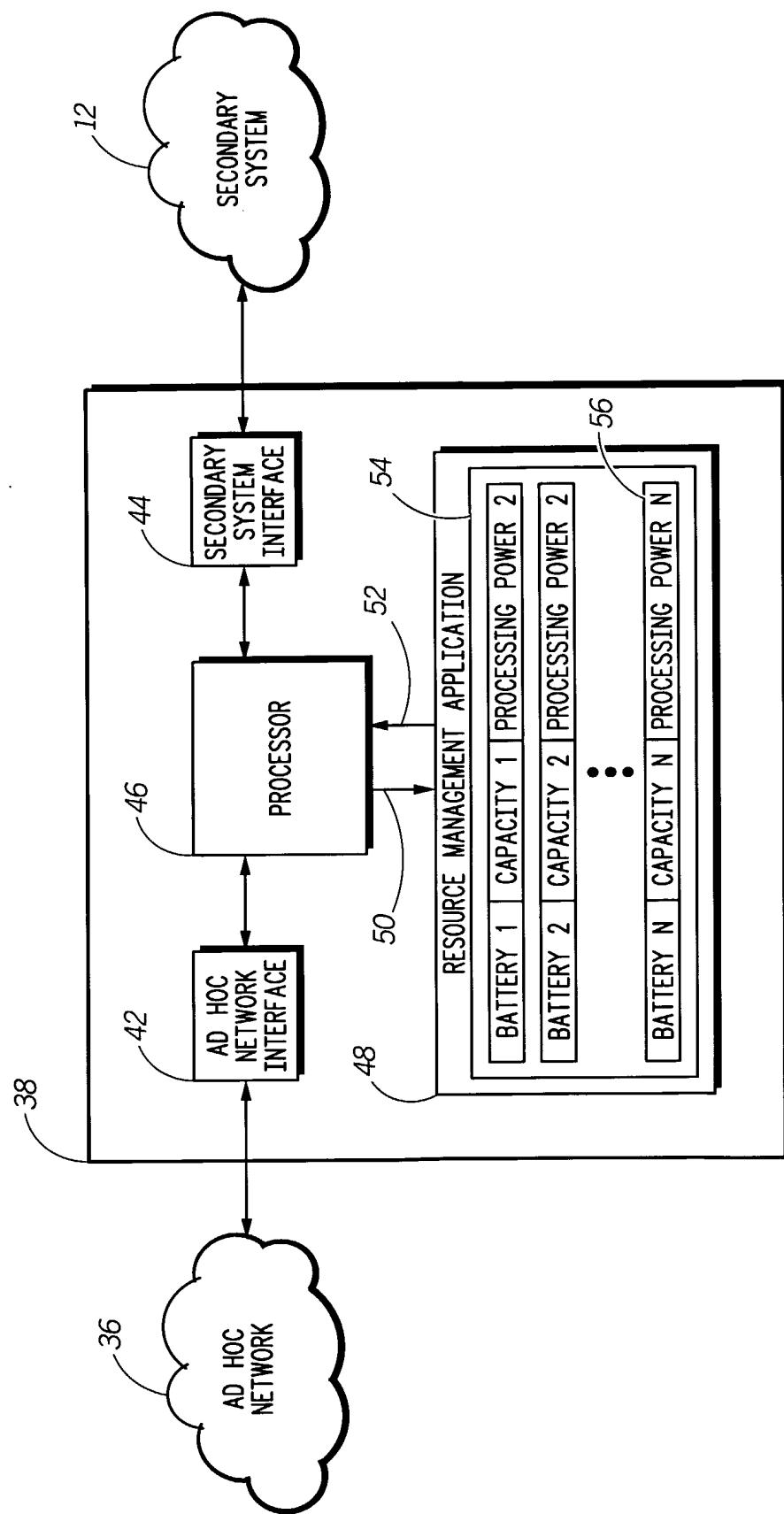


FIG. 3

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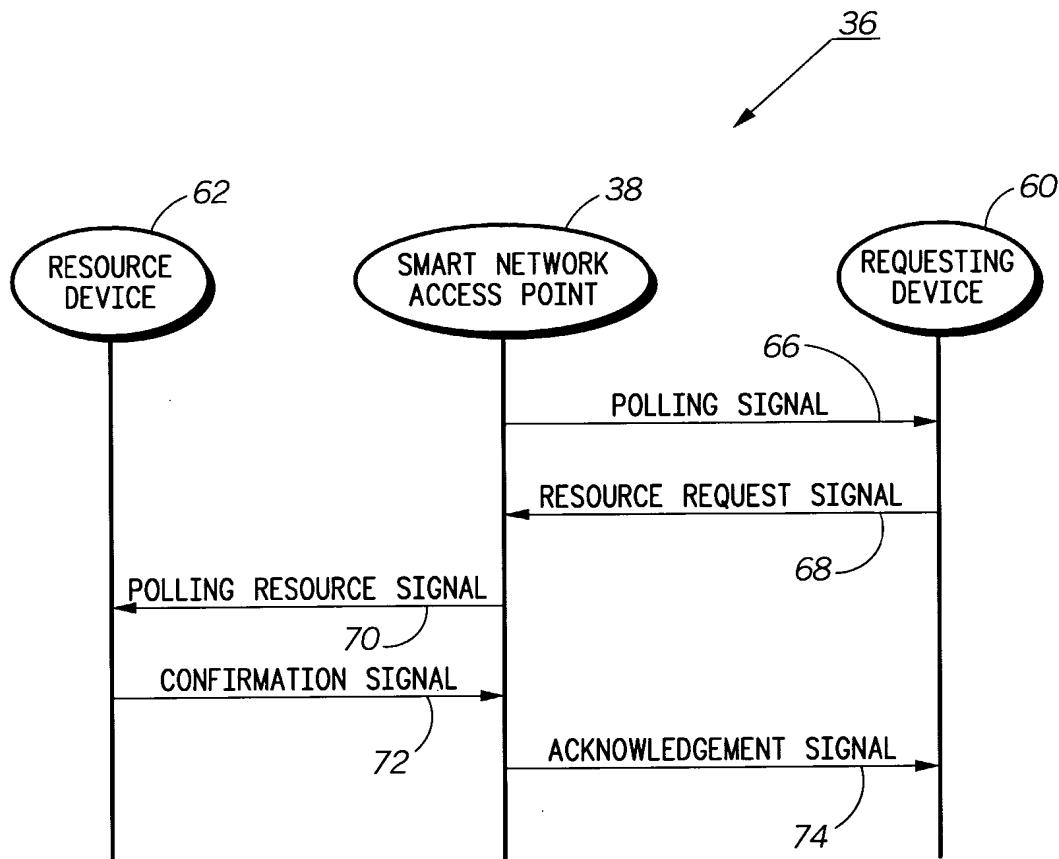


FIG. 4

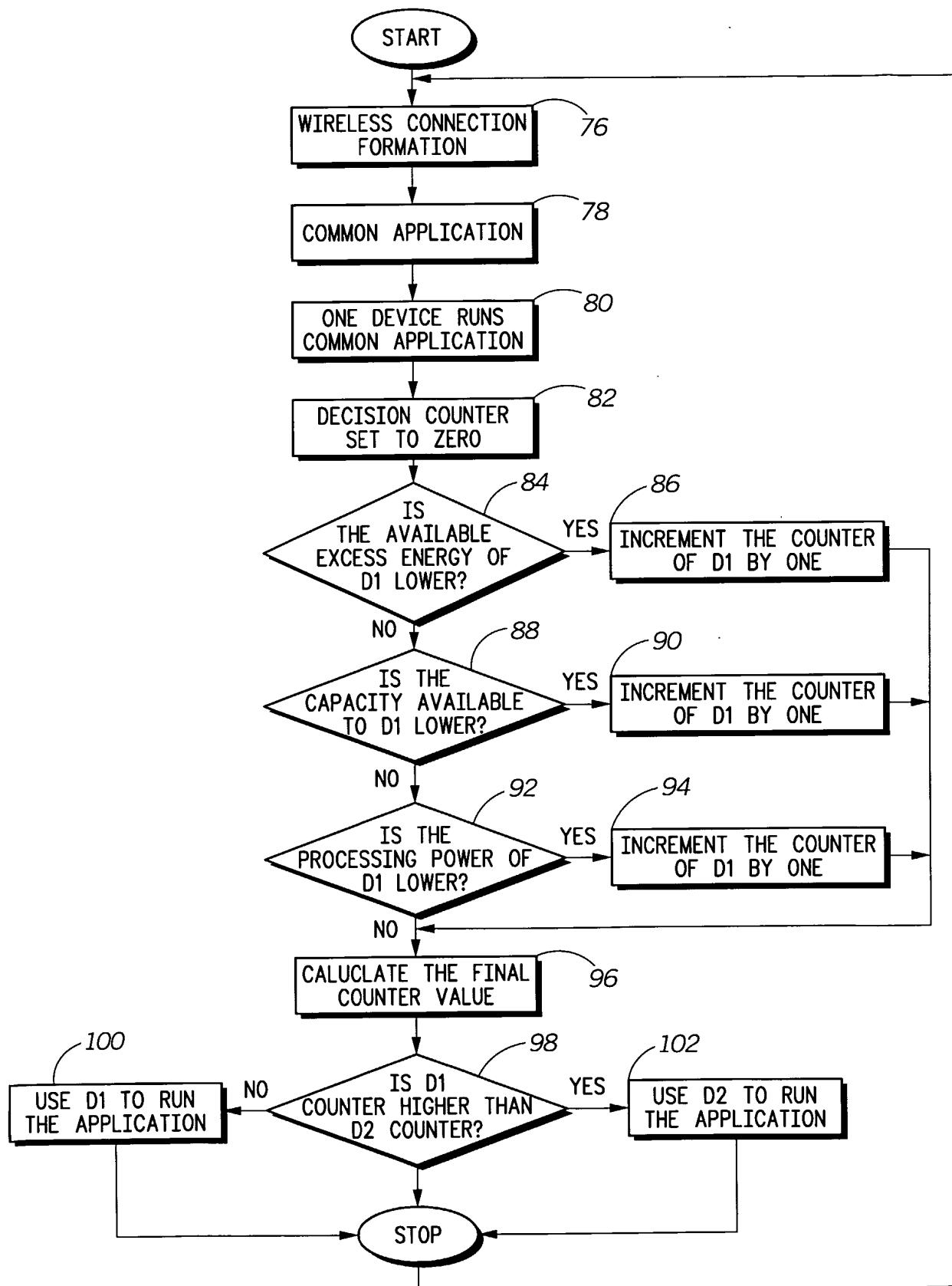


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/10253

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G06F 15/16

US CL :864/200

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 864/200; 395/800, 200.03, 200.11, 427; 370/85.1; 707/103; 709/239, 206

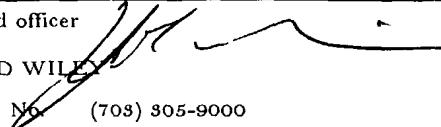
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,835,673 A (RUSHBY et al) 30 May 1989, col. 4, lines 31-50; col. 5, lines 40-54; col. 8, lines 28-53; col. 11, table #1; col. 11, lines 5-61; col. 8, lines 54-68 and col. 9 lines 1-10; all of page 5;	1-10
Y	US 5,745,483 A (NAKAGAWA et al) 28 April 1998, col.2, lines 57-67; col. 3, lines 1-48.	1-10
A	US 5,271,007 A (KURAHASHI et al) 14 December 1993.	1-10

<input type="checkbox"/>	Further documents are listed in the continuation of Box C.	<input type="checkbox"/>	See patent family annex.
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24 JUNE 2002	15 JUL 2002
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